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OFFSETTING NEW CO_2 EMISSIONS: A RATIONAL FIRST GREENHOUSE POLICY STEP

DANIEL J. DUDEK AND ALICE LEBLANC

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OFFSETTING NEW CO_2 EMISSIONS: A RATIONAL FIRST GREENHOUSE POLICY STEP

DANIEL J. DUDEK and ALICE LeBLANC*

This paper describes and assesses a policy to slow the increase of carbon dioxide (CO_2) emissions in the atmosphere. Policy governing new CO_2 sources would either prevent emissions, procure compensating emissions reductions, or sequester emissions in sinks. The paper uses electric power plants to demonstrate the mechanics of the policy and the control or offset choices. Offset options include scrubbing, fuel switching, investments in energy conservation and efficiency, and afforestation.

Costs per ton of CO_2 sequestered range from $1.35 for planting shade trees to $59.41 for scrubbing. All options except scrubbing cost less than $11.00, and the median cost is around $6.00 per ton removed. Planting trees on erodible cropland in conjunction with the Conservation Reserve Program combines the goals of reduced erosion, surplus agricultural production, and greenhouse warming. This policy is a first sane step toward reducing the accumulation of greenhouse gases. Having an international framework for managing emissions is most desirable. In the interim, however, the United States can demonstrate environmental leadership, generate substantial conservation benefits, and spark ingenuity in searching for alternatives, broadening the options, and lowering the ultimate costs of reducing CO_2 emissions.

I. INTRODUCTION

This past year, public attention has focused on the portent of global change. Concerning depletion of the stratospheric ozone layer, an international consensus was developed and an agreement to restrict the production of chlorofluorocarbons (CFCs) was achieved. The huge seasonal ozone depletions over the Antarctic continent demonstrated visibly the human capacity for altering the biosphere dramatically. As awareness of this problem has increased, recognition of CFCs' dual role as both ozone depleters and greenhouse gases also has developed. The unusual weather patterns of summer 1988 created crisis conditions for many weather-sensitive

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sectors of the economy. Drought affected much of the Midwest and Great Plains regions of the United States, and this severely reduced crop yields. The western states were ravaged by forest fires, and this increased the drought's devastation and added to the emissions of carbon dioxide (CO_2)—the single most important greenhouse gas.

These events, coupled with recent scientific assessments presented at Villach, Austria (UNEP, 1988), at Toronto (WMO, 1989), and before the Senate Committee on Energy and Natural Resources (U.S. GPO, 1988), have prompted policy makers to assess governments' appropriate response. Examples of legislative initiatives in 1989 addressing global warming are S. 2667 introduced by Senator Wirth with several co-sponsors and S. 2666 introduced by Senators Stafford and Baucus and others. Many observers recognize the importance of improving energy efficiency and reducing fossil fuel combustion. Ultimate goals for fossil fuel reduction have been set at roughly 50 percent so as to stabilize the atmosphere.[1] However, most policy initiatives remain in the planning or research stages.

Some global warming policies would steer society toward different energy choices through changes in incentives. Others would accelerate research and development so as to avoid future catastrophes. The policy debate currently is focused on the best mix of strategies. The policy that this paper discusses would begin the long process of slowing greenhouse gas emissions and averting some of the warming by requiring CO_2 offsets for new fossil-fueled electricity generation. This would stimulate the development and use of CO_2 reservoirs and low-CO_2-emitting energy technologies, and it would encourage conservation and other measures to reduce CO_2 emissions.

II. GREENHOUSE POLICIES

Managing the greenhouse problem is best conceived in stages. The first task is to slow the rapid growth of emissions in the atmosphere. For some greenhouse gases, such as CFCs, this began in January 1990 when the Montreal Protocol went into effect. For others, such as the CO_2 produced from fossil fuel combustion, one can expect no reduction in emissions growth given the underlying demand for energy. Investments in energy conservation have allowed the U.S. economy to grow significantly while keeping total energy consumption virtually flat over the 1973-1987 period (Hatsopoulos et al., 1988). However, real energy prices also have fallen and have diminished the discipline of the high prices. The mix of fuels used in energy

1. An international conference, "The Changing Atmosphere: Implications for Global Security," brought scientists together in Toronto during June 1988. The consensus was that a 20 percent reduction in fossil fuel combustion would be both desirable and attainable by the year 2005. That same meeting also addressed the 50 percent goal. In the Environmental Protection Agency's (EPA) report to Congress of February 1989 entitled "Policy Options for Stabilizing Global Climate," the EPA states that a 50-80 percent reduction in anthropogenic emissions of CO_2 would be required so as to stabilize atmospheric concentrations at current levels.

production is another critical determinant of emissions. For example, when natural gas is combusted, it emits 26 percent less CO_2 than does residual fuel oil and 43 percent less CO_2 than does coal (per Btu) (Department of Energy Carbon Dioxide Analysis Center, 1989). Many conventional energy analysts forecast an increasing reliance on coal beyond its current 24 percent share of the U.S. energy market (Villagran, 1989).

One way to slow emissions growth and still allow growth in energy production is requiring all new CO_2 sources to offset their emissions—i.e., new CO_2 sources would have to find compensating CO_2 emission reductions elsewhere. Initially, this approach could be feasible if applied to stationary sources, which account for close to 70 percent of total CO_2 emissions in the United States. Fossil fuel-burning electricity-generating utilities account for more than one-half the CO_2 emissions of stationary sources, or about 35 percent of total U.S. CO_2 emissions (U.S. DOE, 1989).

III. OFFSETS

One could generate offsets in a variety of ways. An offset policy requires only that the form of CO_2 compensation be certified, permanent, and enforceable. For example, investments in energy conservation would reduce energy demand, fossil fuel burning, and emissions. Such offsetting investments need not be limited to the service region of an individual utility. If energy conservation investments are more effective in northern regions, then one might exploit these opportunities first. Cogeneration frequently improves the efficiency of energy use and could help obtain CO_2 reductions. Estimates of the electricity that cogeneration will produce during the year 2000 range from 187 billion to 262 billion kilowatt hours (kWh) (RCG/Hagler Bailly, 1989). If this cogeneration replaces coal-fired electric utilities with a mix of coal- and gas-fired cogeneration units, then approximately 110-154 million tons of CO_2 reductions are realized. The higher estimate is more likely to occur if Congress enacts a flexible emissions trading program for acid rain control (Dudek et al., 1990).

One also could make investments in mass transit options so as to reduce mobile sources of CO_2, but these options would likely be expensive. A cheaper opportunity would be expanding van pooling. One could induce appliance or auto manufacturers to improve efficiency by allowing them to generate offsets or requiring them to purchase offsets if average efficiency fell below a pre-set standard. Scrubbing CO_2 emissions from stack gases and then disposing the CO_2 also would constitute an offset. Afforestation, particularly of retired agricultural lands, is another possibility. The following sub-sections describe and analyze the feasibility of several potential offset options. All examples presume an offset ratio of 1-to-1, but one could implement any ratio. In particular, if the effectiveness of an offset option is uncertain, then one would desire offsets greater than 1-to-1.

A. *Biomass Offsets*

Of all the greenhouse gases emitted to the atmosphere, only CO_2 can be readily removed. Some have suggested the widespread planting of trees as one means of removing CO_2 from the atmosphere and storing it as carbon in the biomass of the forest (Dyson, 1976). Sequestering 5 gigatons of carbon from the atmosphere each year—an amount roughly equal to current annual world emissions—would require between 1.3 billion and 1.7 billion acres of new plantation forests (Marland, 1988). By comparison, the total land area of the United States is 2.3 billion acres.

If one doubled the productivity of existing forests, then the same result could be achieved from existing forests through increased uptake of CO_2. One would have to achieve these increases through genetic improvements, management, and fertilization. Existing studies of using trees to control the greenhouse problem demonstrate the lack of technical or physical barriers to use large-scale biomass offsets. Expanding forested area would produce offsetting reductions of CO_2. Joint investments would be possible between utilities and timber companies or the Forest Service. The Conservation Reserve Program (CRP), created by the Food Security Act of 1985, offers another opportunity, particularly since it is under legislative review for reauthorization.

1. *The Conservation Reserve Program*

The CRP is intended to remove highly erodible agricultural land from production. Private landowners offer to convert targeted cropland to non-crop vegetative uses in exchange for annual government payments for 10 years. In addition, the government will subsidize up to 50 percent of the cost of establishing approved conservation practices. The program's goals include 40-45 million acres of cropland under contract in the reserve by 1990 of which one-eighth was to be forested.[2] One bill—S. 1521, introduced June 23, 1987, by Senator Nunn and others—would increase these figures to 55-65 million acres.

Offsetting new CO_2 emissions by increasing afforested CRP land would facilitate attaining both the CRP's conservation objectives and a slowing of CO_2 emissions growth. In addition, offset expenditures would raise the effective cost of building new power plants, and this would make energy efficiency investments relatively more attractive.

2. *Feasibility of Biomass Offsets*

Table 1 presents the CO_2 emissions resulting from new electric power generation expected to come on stream from 1987 to 1996 as well as the

2. Total acreage contracted under the CRP increased to 33.9 million acres during the ninth signup during summer 1989. The CRP will be under review as Congress moves toward a new farm bill in 1990.

TABLE 1
Planned Coal- and Oil-Fired Electric Generating Capacity Increase Through 1996

	Coal-Fired		Oil-Fired		
Year	Megawatts	CO_2 (million tons)	Megawatts	CO_2 (million tons)	Acres (millions)
1987	3,513	20.2	14	0.05	1.4-3.2
1988	2,194	12.6	13	0.04	0.8-2.0
1989	1,834	10.6			0.7-1.7
1991	3,961	22.2			1.5-3.5
1992	2,503	14.4	130	0.4	1.0-2.4
1993	750	4.3	180	0.6	0.3-0.8
1994	2,983	17.2	770	2.6	1.3-3.1
1995	1,600	9.2	538	1.0	0.7-1.8
1996	3,405	19.6	935	3.1	1.5-3.6
Total	22,643	130.2	2,580	8.6	9.3-22.1

Note: Acreage is for offsets required for total CO_2 emissions by new oil- and coal-fired electricity-generating utilities.

Source: Planned electric generating capacity increases are from the North American Electric Reliability Council (1987).

acreage of new mixed hardwood forests required for offsets.[3] (Planned coal- and oil-fired generating stations were taken from the 1987 Reliability Assessment published by the North American Electric Reliability Council.[4]) Plants were assumed to operate at capacity rates of 65 percent for new coal plants and 49 percent for new oil-fired plants. The CO_2 emissions rates used were 202 pounds of CO_2 per mmBtu for coal and 156 pounds of CO_2 per mmBtu for oil.[5]

The authors assessed the feasibility of afforestation by examining the literature on uptake rates for different tree species. Estimates of uptake fall within a wide range since few studies have attempted to measure the total carbon storage potential for different species, soils, and climates. This deficiency results partly from the fact that silviculturalists and forest managers

3. Mixed hardwoods were chosen for these calculations because their average carbon fixation rate is close to the average for all species and because their range of carbon fixation rates is also representative of all species. Variation in acreage reflects variation in both uptake rates of different species and cropland soil conditions for different regions of the country.

4. Planned new gas-fired units were not included. They also contribute CO_2 emissions, though at a lower rate.

5. Estimates were provided by the Department of Energy Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Oak Ridge, Tenn. The calculations in this paper also assume an average utility heat rate of 10,000 Btu per kWh.

have been interested largely in only stemwood or merchantable timber production. However, carbon also is stored in root systems and as detritus and soil carbon. Johnson and Sharpe (1983) estimated ratios of merchantable stemwood to total stemwood in detailed plot studies in Virginia: The ratios ranged from 2.1 to 5.0 and had a mean value of 2.7. On this basis alone, studies inferring carbon fixation rates from typical Forest Service data on merchantable biomass would underestimate total fixation substantially. Supporting these estimates is research indicating that up to 25 percent of tree biomass is stored in roots and that below-ground storage is inversely related to site quality (Keyes and Grier, 1981). Some ecologists have estimated that as much as two-thirds of the carbon stored in terrestrial ecosystems is in soils (Post et al., 1982).

Other studies (Cooper, 1983) have concluded that carbon fixation rates also vary by management objective. For example, the usual forest management objectives of cutting either to maximize profit or to maximize the annual increment of biomass—i.e., maximum sustained yield—produce only one-third as much stored carbon as do management regimes maximizing storage.

Estimates for carbon fixation rates in the United States were obtained from USDA forest service data (Moulton and Richards, 1990). Average carbon fixation rates for a 40 year period were provided by species, geographic region, and soil type. Average values were calculated for wet and dry cropland for all regions of the country. Ranges reflect variation in regions and for wet and dry cropland. Acreage estimates in table 1 were derived using a range of 6.3 to 15.0 tons per acre per year offset by mixed hardwoods such as oak, ash, cherry and maple.

Table 2 presents the acreages of various tree species required to offset the emissions of the planned electrical generating stations. Total acreages vary from 7.6 million to 42.0 million acres depending on the rate of fixation. Because any offset program most likely would employ a range of species in different locations, an average estimate of roughly 13.5 million acres for all species on cropland is quite reasonable. This figure is 34 percent of the CRP's 1990 acreage goal of 40 million acres and is only 23 percent of Senator Nunn's proposed CRP expansion. In addition, President Bush, in his 1990 State of the Union message, called for a program to increase the nation's tree cover by a billion trees per year for the next 10 years.

3. *CRP Offset Program Costs*

If one assumes tree planting at $150 per acre and $25 per acre fertilization costs, then 13.5 million acres of trees would cost roughly $2.4 billion to establish. Rental payments would be $100 per acre per year, or a total of about $1.35 billion per year. Under the CRP, the U.S. Department of Agriculture (USDA) has contributed on average $50 per acre per year to rental payments. The USDA pays up to one-half the cost of establishing the pro-

TABLE 2
Cropland Variation by Tree Species

Years	CO_2 (million tons)	Trees (millions of acres)			
		Mixed Hardwoods	Loblolly Pine	Spruce	All Species
1987-1996	138.9	9.3-22.1	10.8-15.7	7.6-10.2	7.6-42.0

Source: Moulton & Richards, U.S.D.A. Forest Service, 1990.

tective vegetation. As of May 1989, the average USDA cost share for tree establishment was $38.20 per acre.

If one assumes a capital cost of $910,000 per megawatt for fossil fuel utilities as the Department of Energy (DOE) has estimated, then the total cost of the power plants in table 1 is $23.2 billion. Offsetting with reforestation would amount to roughly a 10 percent increase in capital costs. If the USDA continued to pick up its average establishment cost share, then a utility's establishment cost would drop to approximately $137 per acre. Utilities' total program establishment costs would be about $1.85 billion, or roughly 8.0 percent of capital costs. Annual rental payments would drop to $675 million per year, or 0.49 cents per kilowatt hour, if CRP rental payments of $50 per acre were continued. (This assumes continuing the CRP beyond its current 10-year authorization.)

Some researchers have suggested a fixation rate of 24-32 tons per acre per year as an attainable goal for genetic research for some species (Strauss and Wright, 1990). As fixation rates improve, acreage requirements and costs decline. Table 3 shows the variation in utility costs depending on both tree species and cost sharing and assuming average cropland fixation rates for each species. Establishment costs would range between $1.15 billion and $2.45 billion. On a per-kilowatt-hour basis, total costs would fall by between 0.36 and 1.1 cents.[6] Clearly, an offset program would provide substantial incentives for private investment in genetically improving the fixation rates of trees. The average annual costs per ton of sequestered CO_2 range from $3.48 to $10.67 depending on the tree type and cost share option (see table 3). These cost estimates take no account of revenues that could be generated

6. All costs are expressed in 1985 dollars. Establishment costs consist of planting and fertilizing and are spread over a 50-year period at an interest rate of 8.5 percent. Rental costs are assumed to remain constant at $100 per year (in 1985 dollars). One obtains average annual costs per ton by adding total rental payments to the stream of establishment cost payments (deflated by an assumed inflation rate) and then dividing by total metric tons of CO_2 sequestered over the 50-year period.

TABLE 3
Utility Cost Variations by Tree Species and Program

	Trees			
	Mixed Hardwoods	Loblolly Pine	Spruce	All Species Average
Average Acres (millions)	14.0	12.1	8.4	13.5
Establishment Cost—No USDA Cost Share (billions)	2.45	2.12	1.47	2.36
Average Cost per kWh	0.0110	0.0096	0.0068	0.0106
Average Annual Cost per Ton CO_2	10.67	9.30	6.64	10.31
Establishment Cost—USDA Continues Cost Share (billions)	1.92	1.66	1.15	1.85
Average Cost per kWh	0.0057	0.0049	0.0036	0.0056
Average Annual Cost per Ton CO_2	5.49	4.81	3.48	5.31

Note: Dollar amounts are in 1985 dollars.

from harvesting. Any CO_2 losses due to harvesting would have to be compensated. Individual regional economies could benefit from more widespread afforestation.

B. *Biomass Energy Plantation Offsets*

Trees produced in an intensive plantation style of cultivation also could serve as biomass energy source. If biomass from energy plantations is used instead of fossil fuel for new electricity generation, CO_2 emissions are offset. In the plantation rotation system, newly planted trees sequester an amount of CO_2 equivalent to that emitted by the combustion of the harvested trees.

Dramatic increases in productivity of Douglas fir (26 percent) and loblolly pine (more than 100 percent) have been documented (Farnum et al., 1983). However, widespread conversion of existing forested areas—rather than cropland or other unforested land—to biomass plantations could increase the net flux of carbon to the atmosphere (Cropper and Ewel, 1987). This could occur if the older trees, which store relatively large amounts of carbon, are harvested for uses that do not replace the burning of fossil fuels but ultimately are combusted and release their stored carbon as emissions. From an ecological viewpoint, such wholesale conversions to monoculture could be disas-

trous. Fortunately, current economic evaluations of this energy source tend to favor cropland conversion since land preparation costs are dramatically less.

Since the energy crisis of the early 1970s, substantial research has focused on evaluating the potential to supply the nation's energy demand from biomass. Generating electricity through the use of gas turbines fired by gasified biomass has yet to be demonstrated commercially but should cost less than conventional coal-fired electricity generation in developing countries and should be competitive in most of the United States. Advances in coal gasification for use in gas turbines are applicable to biomass. Using cultivated biomass as an energy source not only would provide an offset but would help reverse deforestation in developing countries (Williams, 1989). An offset policy, such as the one outlined in this paper, would provide incentives for developing innovative technology such as the gas turbine powered by gasified biomass.

Results from the Department of Energy's research program indicate that plantation management could sequester carbon at an average cost of around \$8.16 per ton of CO_2 (Strauss and Wright, 1990). This cost could decrease in the near future due to the potential for genetically engineered improvements in the carbon fixation rate. These cost figures are for the plantation and its operation only. They do not include harvest and transportation costs and do not take into account the value of the biomass as fuel.

C. *Energy Conservation Offsets*

The use of energy conservation investments to reduce energy demand and thus avoid constructing new expensive generating capacity is well known. The authors pooled data on program costs of conservation measures in the Midwest, Pacific Northwest, and New York State so as to derive a national conservation cost curve (Dudek et al., 1990). If one utilizes the most cost-effective conservation measures, then a reduction of 138.90 million tons of CO_2—the amount required annually to offset the planned new utility emissions—would cost on average \$5.73 per ton. Costs of the conservation programs selected range from 0.1 to 1.0 cents per kilowatt hour saved.

These conservation investments also would reduce the underlying demand for new generating stations and the demand for offsets. Utility avoided costs from conservation measures include the cost of new capacity. In addition, one also can consider fuel cost an avoided cost from a social viewpoint. When one includes avoided costs, the net costs per ton of emissions prevented would be negative. The offset policy should increase demand for energy conservation investments. Any offset policy will likely result in a mix of options actually selected, and conservation will be one such option.

Over the years, researchers have assembled a wide variety of energy conservation investments and their costs. Some energy conservation investments

combine demand reduction and sequestering. For example, some researchers have suggested planting shade trees around homes so as to reduce air conditioning demand. This option has been estimated to cost between $1.35 and $6.74 per ton of prevented CO_2 (Rosenfeld et al., 1988).

D. *Scrubbing and Disposal*

Another possibility for offsets would be the more conventional approach of treating emissions at the source through scrubbing stack gases. The most economically promising scrubbing technology consists of an absorption and stripping process using monoethanolamine (MEA) (Albanese and Steinberg, 1980).

The critical determinant of cost and feasibility is the disposal method. Disposal options primarily involve deep ocean discharge in either solid, liquid, or gaseous form. At a 90 percent removal level, one can expect power-generating costs to double for a modern, coal-fired, 200-megawatt plant. At an average electricity cost of 60 mills per kWh, this results in a cost of $59.41 per ton of CO_2 removed. Clearly, these estimates are beyond those for alternative offset options. In addition, no certain method exists for storing the CO_2 in the large quantities generated to keep it from re-entering the atmosphere. Even ocean disposal has technical and ecological uncertainties (Steinberg, 1989).

However, one can expect technological change, induced partly by policies such as an offset requirement, as evidenced by new developments in scrubbing technology (*Chemical Marketing Reporter*, 1988).

E. *Fuel Switching*

Fuel switching could result in reduction of emissions from utilities. On a mmBtu basis, the combustion of natural gas results in fewer emissions than does the combustion of either coal or residual fuel oil, and the burning of residual fuel oil results in fewer emissions than does the burning of coal. The cost of switching depends on the relative prices of the fuels and the cost of equipment changes.

Switching from residual fuel oil to natural gas could be a cost-effective way to reduce emissions. The cost of equipment change is not significant in most cases and prices of the two fuels are forecast to remain relatively close over the next 15 years. Over the period 1995-2005, based on estimates of future prices of natural gas and residual fuel oil (GRI, 1989) and of total consumption of oil by utilities (ICF, 1989a), switching from residual fuel oil to natural gas by utilities in the 31 eastern states could result in an average yearly reduction of 46.3 million tons of CO_2 at an average cost of $4.48 per ton reduced (Dudek et al., 1990).

Switching from residual fuel oil to natural gas not only would reduce CO_2 emissions but also would reduce sulfur dioxide (SO_2) emissions. The sulfur

content of oil that utilities burn varies: Resulting emissions are in the range of 0.2-2.8 pounds per mmBtu. Natural gas, however, is generally free of SO_2 emissions. Switching from oil to gas, as described above, also would result in an average yearly reduction of 228,900 tons of SO_2. If the acid rain legislation that the Bush administration has proposed is passed, then one can expect the value of a permit for one ton of SO_2 emissions to be worth more than $700 by the year 2000 (ICF, 1989b). Clearly, an offset policy for emissions would reinforce the acid rain legislation by providing incentives for switching to cleaner fuels.

IV. CONCLUSIONS

The offset policy that this paper has described generally is applicable to all sources of greenhouse gas emissions. Policy measures to slow the continued accumulation of greenhouse gases currently are available. As table 4 indicates, these options range in cost from $1.35 to $59.41 per ton of CO_2 removed. For a new 200-megawatt coal-burning electric power plant requiring total offsets, this would add 0.1-6.0 cents per kWh with a median increase of about 0.7 cents per kWh. If one assumes an average cost per kWh of 6 cents, then the percentage increase in electricity costs ranges from 2 to 100 percent with a median increase of 12 percent. These cost estimates are calculated as a percent of electricity costs of new generation capacity. When offset costs are blended with the cost of total electricity generation by the utility requiring the new capacity, they would be substantially lower as a percent of a rate increase to customers. These cost estimates do not account for the value—often substantial—of other benefits deriving from the offset policies. These include the harvesting of trees for commercial uses, the use of biomass for fuel, avoided costs from conservation, and SO_2 reduction from fuel switching.

Emissions from planned fossil fuel-burning power plants have been used as an example to demonstrate the offset policy. However, one could include mobile sources as well. Auto manufacturers voluntarily could improve fleet fuel efficiency beyond the regulatory requirement. One could translate these fuel efficiency improvements into present-value terms through the use of actuarial methods and then sell them as offsets. Appliance efficiency improvements would provide a similar opportunity.

The final question: What do these offsets achieve? The cumulative outputs of the proposed new plants would account for less than 3 percent of total U.S. emissions. Because the problem is the growth rate of emissions, one must begin to chip away at the problem as opportunities arise—particularly when one can combine several public policy objectives. A single, cheap technical solution to the greenhouse problem does not likely exist. Rather, progress probably will come one small step at a time. Some of these small steps can be marginal policy changes but, when summed, can have a potent effect in reducing greenhouse gas emissions. These estimates seem small but

TABLE 4
Costs of CO_2 Offset Options

Option	Cost per Ton CO_2
Trees With CRP Contribution	$3.48-$5.49
Trees Without CRP Contribution	$6.64-$10.67
Biomass Plantation	$8.16
CO_2 Scrubbing and Disposal	$59.41
Shade Trees	$1.35-$6.74
Conservation	$5.73
Fuel Switching (oil to gas)	$4.48

are based only on the direct offsets and not on any additional conservation that the increased energy production costs induce. The policy would produce incentives to reduce emissions requiring offsets, to develop and deploy less intensive energy technologies, and to exploit carbon sinks. Further, retiring agricultural lands also would generate greenhouse gas emission savings from foregone agricultural operations if one elects the CRP option.

Linking an offset program with the CRP also answers the thorny question of the CRP's fate after the 10-year contracts expire. The history with similar land retirement programs indicates a general failure to follow through. Previous efforts aimed at creating a soil bank proved to be temporary as congressional support waned. An offset policy could provide permanence to the CRP and could secure lasting environmental benefits by providing a stream of income beyond the 10-year life of the program for forested acreage. And finally, offsets would stimulate the search for new and cheaper ways to eliminate emissions—a pressing national priority.

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Cost of ton of coal = $25. ↑ $5 ↑ ⇒ 30.00 (a 20% ↑)
5¢/Kwh of which coal cost is 2.5¢
20% ↑ ⇒ coal = 3¢ ⇒ total Kwh cost = 5.5¢ — ↑ of 10%.

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ENVIRONMENTAL DEFENSE FUND

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October 30, 1990

Mr. William K. Reilly
Administrator
U. S. Environmental Protection Agency
1200 West Tower A-100
401 M Street SW
Washington, D.C. 20460

Dear Mr. Reilly:

As we near the end of almost two years of hard work on the acid rain title of the Clean Air Act, I am writing to express my personal pleasure in working with you. Without your support and continued attention to the substance as well as the process, the critical policy innovations embedded in the Act would have been lost. It is truly a delight to find a constituency for efficiency.

I am sure that your agenda has already been filled to overflowing with other issues. However, I would like to point to the incredible opportunities that this Act contains for greenhouse gas sensitive investments, a fact that the Administration itself has used to advantage. What is missing is the nudge to make those investments happen. I am attaching a copy of what was probably the last piece of legislation introduced in the 101st Congress. It has been introduced by Representatives Cooper and Synar, two friends of market-based approaches. The Bill would require new sources to acquire CO_2 offsets and create the administrative machinery to certify CO_2 offset credits.

The Bill would capitalize on the strengths of the acid rain provisions in the Clean Air Act and begin to lay the foundation for the comprehensive greenhouse gas trading program that we will need in the future. It will also generate incentives for new technologies to be developed and deployed.

I hope that you will make some time available in your busy schedule to review this proposal. As always, I would be pleased to discuss any aspect of this proposal with you or your staff.

Sincerely,

Daniel J. Dudek
Senior Economist

DJD/mm

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agencies from litigation. A DOD source suggests that federal agencies may be sued for not fulfilling NEPA, despite an Oct. 2 DOJ memo arguing that NEPA does not apply to CERCLA cleanups initiated by federal agencies. This source says the DOJ opinion is not sufficient to block citizen suits, and since fulfilling NEPA takes only a small additional effort beyond the RI/FS, questions the wisdom of "go[ing] out on a legal limb" by not completing it. Another Administration source says CEQ has maintained that an EIS addresses ecological and wildlife concerns that CERCLA does not. EPA staff acknowledge that Superfund has tended to focus first on human health risks. Administration sources also argue that NEPA requires more public input in remedy selection, which may lead to greater public acceptance of the eventual remedy, thereby preventing litigation later.

Dropping NEPA would be a vote of confidence for EPA, because EPA has primary oversight authority for CERCLA while CEQ oversees NEPA, an environmentalist argues. This source suggests that NEPA "takes crucial decisions out of the hands of the regulators" at EPA and turns them over to officers of the other involved agencies. Another environmentalist suggests the dispute over NEPA may be little more than a power play between agencies, with EPA trying to maintain control over cleanups and other agencies trying to take some authority under NEPA. But EPA, CEQ and DOD sources all say the NEPA/CERCLA debate will not engender any shift in authority, and none of their agencies are looking at the debate as a power struggle. These sources say the battle is simply a philosophical debate between agencies trying to craft the most efficient method of environmental protection.

MOST COST-EFFECTIVE GREENHOUSE PLAN MUST TARGET WORST GASES, NEW STUDY SAYS

Certain greenhouse gases are far more potent than carbon dioxide in terms of global warming potential, a new EPA-prepared analysis finds, and the U.S. must consider this in determining the most cost-effective approach for tackling the problem. Many following the global warming debate have associated carbon dioxide as the most harmful of the greenhouse gases, because it is the most pervasive. But in fact other gases possess more heating potential -- such as methane, which is 21 times stronger than CO2 -- and must be reckoned with accordingly, the new study says.

382-5440

The EPA analysis, *The cost of reducing greenhouse gas emissions in the United States,* was prepared by Alex Cristofaro, director of EPA's air & energy policy division in the Office of Policy, Planning & Evaluation, for a Dec. 4-5 conference. The conference, *Global climate change: the economic costs of mitigation and adaptation,* organized by the Center for Environmental Information, Inc., was partly funded by EPA.

Existing federal programs may be adequate to limit greenhouse gas emissions in the U.S. to today's level on a per capita basis for the next 10-20 years, Cristofaro concludes: "This is because current government energy and environmental policies are sufficient to keep total greenhouse gas emissions (expressed as carbon equivalents) below 1987 levels in the year 2000. In 2010 total emissions are projected to be only 4% above current levels in one scenario and essentially the same as 1990 levels in another." But, he notes, CO2 is projected to grow, so "if the goal is stabilization of the absolute level of CO2, additional government control programs would be necessary."

The analysis says several opportunities exist for reducing U.S. greenhouse gas emissions. But the way the U.S. chooses to do this will be critical from a cost-benefits standpoint. For instance, Cristofaro points out that NOx emissions trap 40 times more heat than CO2, so that control costs of $400/ton for NOx would be as cost-effective in reducing warming as CO2 controls that cost $10/ton. More importantly, NOx controls would offer other environmental benefits. "NOx deposition has been identified as an important contributor to nitrogen loadings in water bodies and NOx plays a role in the formation of tropospheric ozone, visibility impairment and acid deposition. These benefits should be taken into account in analyzing the economic efficiency of reducing GHGs," the analysis says.

Since methane is a significant greenhouse gas, 21 times more potent than CO2, control opportunities should not be overlooked, the analysis says. Cristofaro notes that animal waste is a large source of methane, but points out that promising technologies currently exist for methane recovery which could both reduce emissions by almost 50% and generate electricity at a cost of five to seven cents per kilowatt hour. With regard to methane, Cristofaro emphasizes, ". . . the lack of data on methane control could be rectified in the near future. The Clean Air Act Amendments of 1990 require EPA to issue a report to Congress on methane emission inventories and control costs."

Opportunities for NOx reductions remain as well. Cristofaro suggests low NOx burner controls could be broadened to cover existing industrial boilers and small electric utility boilers. Carbon monoxide, which is eight times stronger than CO2, will be limited under the new Clean Air Act, but the extent of CO controls

of hazardous waste in the next 10 years. But the report finds that because states are not in the business of hazardous waste treatment and disposal -- a task left largely to the private sector -- it is difficult, if not impossible, to predict trends in capacity for the next 20 years. To relieve the uncertainty, the report recommends that Congress refine the law to more clearly spell requirements for waste reduction, the siting of facilities and disputes among states which have waste management capacity versus those that don't.

The CEM report will also recommend that EPA provide additional guidance to states for the preparation of hazardous waste projections and that data collection and planning methods among the states be standardized. The report will suggest that Congress rethink whether threatening to revoke Superfund monies from non-complying states is a constructive provision, and that Congress consider the state and federal role in providing waste management services since that is currently chiefly a private sector function.

Battle with White House looms

EPA STAFF SPAR OVER WHETHER ENVIRONMENTAL STUDIES BLOCK FEDERAL CLEANUPS

In what is proving to be a major policy debate, EPA is struggling internally and with the White House over whether certain environmental assessments improve or interfere with cleanups at contaminated federal facilities, agency sources say. Administration sources say resolving the issue could determine how much input the public has in choosing a cleanup or asking courts to review remedies selected at government-owned Superfund sites.

The debate centers around whether conducting the preliminary study required under Superfund -- the remedial investigation/feasibility study (RI/FS) -- satisfies legal requirements that federal agencies conduct an environmental impact statement (EIS) to weigh environmental consequences of various possible actions. The Justice Dept. says it does, and EPA is apparently attempting to draft a policy concurring with DOJ. The White House Council on Environmental Quality, which oversees the EIS process under the National Environmental Policy Act (NEPA), argues the EIS is a legal requirement for all cleanups, and that it tends to provide better environmental protection than just an RI/FS. EPA is split on the issue: some staff agree with CEQ, but agency officials are leaning towards a policy decision limiting NEPA requirements because they say it adds an unnecessary burden that will slow cleanups.

Administration sources say they have sought a resolution of the debate for over two years, but that federal agencies currently have half a dozen differing policy statements on the issue. Environmentalists and congressional staff say the debate may be motivated by a turf battle between agencies, but sources in several federal agencies dismiss that view as overly cynical. Nevertheless, these sources acknowledge that the issue has provoked a heated interagency debate which may have no easy resolution.

NEPA requires federal agencies to submit an EIS for all major proposed actions. EPA is generally exempted from the EIS process on the grounds that, since the agency's primary role is environmental protection, its actions necessarily contain the "functional equivalent" of an EIS. Administration sources suggest EPA and DOJ are seeking to have other federal agencies' cleanup actions under the Comprehensive Environmental Response, Compensation & Liability Act (CERCLA) exempted from NEPA as well, but EPA sources acknowledge the agency is deeply divided over the issue. CEQ, which has primary authority for NEPA, opposes the exemption, apparently on the grounds that a NEPA EIS provides a broader range of federal and public input into cleanup decisions. Administration sources say the Defense Dept. has no single policy, but the Navy, Army and Air Force have individual plans for fulfilling environmental requirements at Superfund sites. An Energy Dept. laboratory released a report in July 1990 spelling out how the two sets of requirements could be satisfied simultaneously. EPA staff say they hope to meet Dec. 10 to draft an agency position which they will submit to CEQ for negotiating a single federal policy.

EPA will most likely come out in favor of reducing NEPA requirements, if not abandoning them altogether, agency sources say. EPA staff say the agency seems to have narrowed its choices to two options: 1. NEPA does not apply where a CERCLA RI/FS is performed; or 2. a CERCLA RI/FS can be slightly extended to fulfill the requirements of a NEPA EIS as well. Agency staff say their primary concern is that completing an EIS in addition to an RI/FS simply adds more paperwork and takes more time and money without reaping any extra environmental benefit. "If NEPA applies, it could slow the process" of remedy selection, one agency source argues. In addition, EPA staff say if NEPA does apply, environmentalists and citizen groups may block progress through legal action which is prohibited under CERCLA. CERCLA allows no legal action until after a remedy has been implemented, while NEPA has no such timing requirements. One EPA source worries that this technicality will allow citizens to initiate legal action earlier in the process, further slowing cleanups.

But other Administration sources argue just the opposite: that complying with NEPA protects federal

could also be extended, geographically and temporally, since currently they are only required in severe nonattainment areas and in the winter months. Cristofaro also says the fuel oxygenate requirements in the new bill could be bumped up to further reduce CO.

Following is a chart from the study which indicates how ongoing programs will affect carbon emissions.

Table 3
Effect of Recently Announced Government Program on Carbon Emissions
(Reductions In Tonnes of Carbon)

ACTION/PROGRAMS	2000	2010
DOE Appliance Standards (Refrigerators, Washers, Dryers, Dishwashers)	4.4	4.9
DOE Efficiency Initiatives	27.8	55.7
Federal Building Lighting	1.4	2.8
Commercial Buildings Lighting	2.5	5.0
Promote State LCUP	9.0	18.0
State Adoption of Interim Building Standards	8.2	16.4
Energy Analysis and Diagnotic Centers	6.0	12.0
HUD Adoption of DOE Building Standards	0.8	1.6
DOE Renewable Initiatives	4.1	4.1
Expanded Hydro Power	3.5	3.5
Photovoltaic Technology	0.5	0.5
Clean Air Act		
Acid Rain	16.4	19.1
Transportation Biofuels	0.8	1.6
GRAND TOTAL	53.5	82.6

BUSH SCIENCE ADVISOR BLOCKS EPA STUDY LINKING EMF TO CANCER . . . begins page one

leukemia (Inside EPA, July 6, p1). Agency officials at that time denied they were downplaying risks, arguing instead that EPA's guidelines for listing carcinogens require specific evidence that is not yet available for EMF. That earlier report was updated and prepared for a Nov. 27 release, but during last week's briefing on the new draft Bromley "had reservations about the quality of the science" and the wording of the report, according to one agency source.

This is the first time the agency has been directly told not to release a report, according to one agency source, who adds that "we're very upset about it here." The action "is very significant," the source says. Another agency source, however, defends Bromley's action, commenting that there is "less than meets the eye" in his intervention. Bromley was merely concerned that much of the report discusses "causation" when it should use the weaker term "correlation" to describe evidence that electricity is linked to cancer. He was also concerned that the report is "so sensationally written that it might cause needless concern" among the public, the source adds. One agency source refused to discuss the matter, saying only that "our document has been postponed" and that "all levels of the agency are involved" in trying to resolve the issue.

EPA, with Bromley's concurrence, still plans to send the report to its Science Advisory Board for review, at which point it becomes available to the public, explain sources. One agency source says Bromley must not be aware of the fact that the report will be made public once SAB receives it, because he agreed the advisory group should conduct its review simultaneously with a White House review. If the public

cannot have the report, neither can the SAB, this source says. But Bromley wants the advisory group to refrain from reaching final conclusions until a White House science group completes its own study of the report, this source adds.

The White House review group -- the committee for interagency radiation research & policy coordination (CIRRPC) -- has been formed under Bromley's Office of Science & Technology Policy to summarize and evaluate the EPA report. Reviewers for the group, to be selected from ten different disciplines, cannot have had any previous experience with the agency's EMF data so they can "make a decision from a fresh view" after reviewing the literature, says one source. CIRRPC will try to complete its report by June, a schedule that is admittedly "ambitious," says this source.

EPA assistant administrator for Research & Development, Erich Bretthauer, was scheduled to meet with Bromley Nov. 30 to discuss the issue. But Bromley accompanied President Bush on his trip to South America and was thus unavailable for the meeting. Another meeting will probably be scheduled next week, an agency source says.

Gearing up for RCRA

EPA STAFF SET SIGHTS ON RESOLVING THORNY ISSUE OF SOLID WASTE DEFINITION

EPA staff this week hope to get closer to resolving the long-standing controversy over whether toxic material destined for reuse in the production process should be regulated as hazardous. The issue, which centers on the definition of solid waste and recycling, was the focus of a major meeting the agency sponsored among diverse interests and will be one of the central questions to be dealt with in Resource Conservation & Recovery Act reauthorization. Industry groups generally have argued that regulating solid waste destined for reuse will discourage recycling, while environmentalists have contended that, if unregulated, certain recycling practices could seriously endanger surrounding areas and populations. The confusion over the definition of solid waste has led to the proliferation of so-called "sham recycling" facilities, where operations profess to recycle in order to escape stringent hazardous waste regulations.

As part of its effort to gear up for the RCRA debate, EPA's office of solid waste is hosting a diverse gathering in Richmond, VA Dec. 5-7 to flesh out the thorny dilemma posed by the definition of solid waste waste and how it relates to recycling (Inside EPA, Nov. 30, p3). Several of the participants have prepared papers on the topic, outlining their views. EPA staff say they are hopeful the group can make progress toward resolving the definition problem, which has resulted in a battle royale between industry groups and environmentalists for the past several years.

Following are excerpts from some of the participants' papers.

American Petroleum Institute. API notes that in order to be a solid waste, a material must first be discarded. But, continues API, "The confusion arises by labelling any and all . . . recycled materials as 'discarded materials,' thereby lumping recycled materials into the same category as materials that are intentionally thrown away. It would appear that this approach presumes that all recycled materials are useless, which is of course not the case. Of greater concern, however, is the negative impact this current regulatory approach has on the recycling of secondary materials. . . secondary materials containing recoverable components or those in need of minimal reclamation prior to reuse, should not ipso facto be labelled a 'waste,' particularly where there is no intention to discard prior to reclamation or reuse. Recycling of secondary materials should be encouraged as part of the hazardous waste management solution, rather than be regulated as part of the problem."

Interior Dept.'s Bureau of Mines. "Congress intended that RCRA provide at least some level of encouragement for recycling, a point not necessarily recognized in the implementing regulations. There are hazardous wastes that can be effectively and safely processed by primary and secondary metals and minerals producers and at the same time reduce the need for raw materials. If these facilities were required to come under the draconian RCRA permitting process to continue such activities, most would terminate such activities. Is this really in the national interest?"

Chemical Manufacturers Assn. "EPA must take a fresh look at what constitutes legitimate recycling, reclamation, and material reuse to assure new regulations encourage legitimate activities. Such activities should include all forms of recycle (sic) in which a material is returned to a manufacturing process so long as the material is not accumulated speculatively and use of the product does not constitute disposal."

Natural Resources Defense Council. "The types of material collected for recycling clearly pose a hazard . . . They include solvents, paints, waste oil, inks, precious metal sludges, lead batteries, steel mill dust, acids . . Clearly, then, a regulatory exemption for recycling cannot be justified on the basis of a benign nature to the materials handled during the recycling process. Nor can an exemption for recycling be justified on the basis of the management of these toxic materials during recycling. The worst of recycling operations commonly entail storage of materials in unlined pits . . ."

certification that the facility's discharge has been tested for illegal "non-stormwater discharges."

Facilities must describe management controls "appropriate for the facility" and implement such controls. In addition to an implementation schedule, facility controls must include a "pollution prevention committee"; a risk identification and assessment/material inventory; preventive maintenance; good housekeeping; spill prevention and response procedures; stormwater management; sediment and erosion prevention; employee training; visual inspections; and recordkeeping and internal reporting procedures. For "facilities subject to SARA [Superfund Amendments & Reauthorization Act] title III, section 313 [reporting] requirements," special requirements will apply. For instance, at a minimum, where section 313 chemicals are "stored, processed or otherwise handled," a facility must provide "containment, drainage control and/or diversionary structures," unless impracticable. If impracticable, a "strong spill and contingency plan" and other requirements must be met. Other special requirements are described for construction activities.

Besides describing the pollution prevention plans and management controls required under the general permit, the proposal lays out monitoring and reporting requirements for different industry sectors. It also discusses the whole effluent toxicity testing requirements and lists a host of "standard permit conditions" that appear in EPA's permit regulations. For instance, permittees "shall comply with effluent standards or prohibitions established under section 307(a)" of the Clean Water Act, will face up to $25,000/day penalties for violations, and must meet other conditions applicable to EPA permits overall.

MAJOR PAPER RECYCLER PROPOSES MODEL BILL TO CREDIT RECYCLING PRACTICES

One of the nation's largest wholesalers of recycled paper will this week propose model legislation that would offer rebates to recyclers and place a waste disposal fee on mills that produce paper directly from trees. The proposed legislation comes at a time when Congress is preparing to reauthorize the nation's solid waste law, which is likely to contain some sort of fee on the use of "virgin" or first-time raw materials use. Last year, a House subcommittee proposed a Resource Conservation & Recovery Act bill that included measures for creating market-place incentives to encourage the use of post-consumer waste. Congressional sources say this is likely to be taken up in next year's RCRA reauthorization package.

Conservatree Paper Company, based in San Francisco, CA, at presstime was slated to unveil its model plan, called *Agenda for the '90s*, at a Dec. 6 press briefing. The company earlier this year gained attention by criticizing EPA for labelling paper "recycled" even if it had never been used by consumers, and for planning to call paper made from sawdust "recycled" (Inside EPA, July 13, p5). Conservatree says that Congress must pass RCRA amendments to stimulate recycling. In a draft statement, company president Alan Davis says: "If EPA had done its job over the past 15 years, none of these strong actions would be necessary. But the situation today is urgent: unless market demand increases immediately, no new mills will be built with the capacity to divert waste paper from landfills." EPA sources discard the charge that the agency has done nothing and say that they are actively involved in exploring options to encourage recycling. "Everyone is looking at how much we can recycle" in each different EPA program office, an agency source says.

The legislation would be revenue neutral, so that the fees collected on the use of virgin paper would go towards paying for recycling incentives. The model bill would impose a disposal fee on sales for those who manufacture virgin paper, beginning with 1% of sales in 1992-95, 2% of sales in 1996-99, and on 3% of sales in the year 2000 and after.

Conservatree estimates that their project will save as many as 462-million trees; the energy equivalent to heating 13.8-million homes; 190.3-billion gallons of water; and $1.8-billion in taxpayers' savings. Additionally, the company estimates the project would reduce air pollution by 1.6-billion pounds and solid waste by 81.6-billion cubic yards.

DEMOCRATS' REJECT BID TO HOLD ENERGY & COMMERCE MEMBERS SOLELY TO COMMITTEE

A House Democratic leadership group this week unanimously rejected a plan that would have forced any future members of the House Energy & Commerce Committee to forego membership on other congressional committees, surprising congressional staff who thought the proposal was uncontroversial. The move to make Energy & Commerce an "exclusive committee," meaning members cannot serve on any other committee, was reportedly initiated by House Speaker Thomas Foley (D-WA), whom sources said would have gained power from the arrangement. With members unable to hold seats outside Energy & Commerce, more seats on other committees would be available and Foley could help members gain those seats, thereby accruing a certain amount of additional power, explains one congressional aide. But the initiative was soundly defeated by members of the Democratic Caucus, who met Dec. 3 to vote on that and numerous

rules within the next six months creating a petition process for adding or removing pollutants from the list, but Farmer insists that the burden of proof has shifted from EPA to industries, which he views as "a major step in the right direction . . . now it's just a question of moving forward."

By the same token, Farmer suggests that air toxics rules in general are written so that delays will not interfere with environmental protection. This makes it far more likely that industry will be more cooperative with the agency, Farmer says. For example, Farmer says that EPA has specific deadlines for setting maximum achievable control technology on various source categories. These rules essentially take effect once the deadline passes whether the rulemaking process is finished or not. In this manner, industry has nothing to gain by delaying promulgation, and instead has incentive to get involved early through comments and negotiations. "They can't play games with us . . . it's in their interest to get in and be cooperative," Farmer says.

Overall, Farmer believes "EPA came out really well . . . we got 80% of what we went in asking for" in the Administration bill. "We're content and we've got a full plate . . . now there is just so much work to be done."

EPA DRAFT REG DETAILS FIRST-TIME TOXICS CONTROL FOR STORMWATER DISCHARGES

A new EPA proposal will for the first time spell out specific requirements for certain industrial stormwater discharges, including requirements that they meet regulatory limits for toxic pollutants. The requirements -- applicable to industrial facilities that must report toxic releases under Superfund -- will include regulatory limits for complex mixtures of toxic chemicals called "whole effluent toxicity," according to an EPA draft general permit for industries. The requirements for meeting "whole effluent toxicity" limits are likely to be especially controversial because such tests have been hotly disputed by the regulated community. Publicly owned treatment works, for instance, have strongly opposed EPA's policy which states that failure of a single "toxicity" test constitutes a violation, arguing that the test results are too variable and uncertain for strict enforcement (Inside EPA, Sept. 7, p11).

EPA on Oct. 31 issued its final rule describing who must apply for a stormwater discharge permit (Inside EPA, Nov. 9, p3; Nov. 2, p1), but did not specify what requirements the agency will impose on permit applicants. The follow-up implementation rule, scheduled to begin Office of Management & Budget review this week, details EPA's proposed requirements for various types of industrial activities that discharge the pollution. Stormwater, which is polluted rainwater collected and discharged through pipes, is considered a significant remaining source of water impairment. The problem is more complex than in typical permit programs which tackle predictable, steadily discharged effluent from facilities and other "point sources." Stormwater involves dispersed "non-point source" pollution that is collected and funneled through pipes, which now must be permitted and in many instances will be required to meet numerical regulatory limits.

Although stormwater pipes will for the first time require permits nationwide, EPA will rely predominantly on enforceable stormwater management plans to achieve the regulatory limits and other goals. Dischargers will be required to develop and implement the plans, subject to enforcement actions under the Clean Water Act. But only in very rare instances is costly treatment of the stormwater likely to be required, depending on specific site conditions. Over 100,000 facilities will be affected by the new requirements, along with 173 cities and 47 counties with their own permit requirements. To make the program for industrial permits manageable, EPA has developed a "general permit" indicating conditions and requirements all facilities under the permit must meet. That draft permit, *obtained by Inside EPA*, is the core of EPA's strategy for controlling industrial stormwater pollution, though some facilities will be covered by individual permits or "alternative" general permits.

"A stormwater pollution prevention plan shall be developed by each facility covered by this permit," according to EPA's draft. The plans must be prepared "in accordance with good engineering practices." They shall be completed within 180 days of the permit's effective date and must "describe and ensure the implementation of practices" that will reduce pollutants in stormwater. Compliance with the plan is required within 365 days of the permit's effective date. EPA's regional offices that will review plans may reject them as inadequate.

At a minimum, plans must include a description of "potential sources" of stormwater pollution, such as illegal connections that are used to dispose of pollution into stormwater systems and loading or unloading of materials that could cause contamination. To help develop an accurate description of potential sources, plans must include "at a minimum" such things as a site map showing each drainage discharge structure and other related site structures; a description of fuels, raw materials and other potential pollutant sources stored on the site now or in the past; a description of current controls for stormwater; and a

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A SHORT DISCUSSION OF GREENHOUSE GAS TRADING

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Prepared for the

Keystone Global Warming Dialogue
Policy Evaluation Working Group

August 1990

1 Emissions Trading Concept

This paper will develop both an argument for the use of greenhouse gas permit trading as well as a startegy for its implementation. The argument for permit trading is based upon the assets of the policy itself and not upon a comparison with other policy instruments. For a comparison of marketable permits with alternative instruments see Dudek (1987). The focus in this paper is on implementation. As such, marketable permits for greenhouse gases can be seen as a natural outcome of the evolution of market-based environmental policy experiences in the U.S. The transition from emissions trading in nonattainment areas to national SO_2 trading through lead rights trading among refiners and transferable production permits for CFCs is very clear. The transition to greenhouse gas trading is from SO_2, to international SO_2 exchanges between the U.S. and Canada, to CO_2 monitoring and reporting, to CO_2 sensitive investments induced by a new source CO_2 offset requirement.

2 Short History of Emissions Trading

Emissions trading is actually a generic term for a collection of flexible air pollution policies created to overcome the conflicts produced by the failure to meet air quality goals in urban areas in the late 70's. The EPA's final emissions trading policy includes provisions for bubbling, offsetting, and netting. Tietenberg (1985) provides an excellent overview of the development of these policy reforms for the management of air emissions. Over time, these basic concepts have been applied to a wider number of pollutants and circumstances. Emissions trading is ideally suited for the management of transboundary pollutants such as acid rain.

The concept of emissions trading is based on the premise that pollution reductions can be accelerated if polluters are allowed to optimize pollution control investments. The evidence from the experience with trading clearly shows significant cost savings for emitters (Dudek and Palmisano, 1988). The environmental account has been more hotly disputed however. Both Hahn and Hester (1986) and Liroff (1986) in their reviews of the performance of netting and bubbling respectively observed no significant deterioration in air quality.

The system operates quite simply. Polluters are assigned a baseline for each emissions source which establishes the initial conditions from which reductions can be assessed. Baselines are established by regulation by the appropriate air quality management authority. The polluter must meet the minimum standards in force for each pollutant at each source. However, these regulatory obligations can be met by overcontrolling at another emissions point and transferring the overcontrol. The flexibility provided by the ability to transfer overcontrol is the heart of emissions trading. It encourages firms to search for cost-effective reductions. When coupled with the prospect of trade outside the firm (for offsets or in the case of the acid rain trading proposal), the incentive of revenues for emissions reductions is added. Institutional innovations such as emission reduction banking and recordation functions reduce the transactions costs of extra-firm transactions.

It is important to point out that a tradeable permit system is a supplement to a regulatory program that establishes overall limits on emissions of CO_2 or, as a surrogate, limits on combustion of fossil fuel or deforestation. The trading system is designed to introduce flexibility in economic decisionmaking by allowing regulated sources to increase emissions above regulatory limits through the purchase of emission credits or to acquire income from the sale of such credits when they emit regulated pollutants below prescribed limits while encouraging investment in pollution reductions beyond minimum requirements. This is the essence of "harnessing the power of the market".

Before describing a trading program at either a national or international level, the regulatory framework must be described. Initially, as a simplifying assumption, consider only one greenhouse gas - carbon dioxide. If, through an international convention or even a series of bilateral conventions, nations want to achieve controls on emissions of CO_2 one approach, based on the Montreal Protocol experience, would be for those countries to establish goals and then allocate the total loadings authorized by the goals among the cooperating nations. These goals and allocation system must take into account environmental objectives, economic efficiency needs and international equity concerns.

For an international agreement to achieve limits on global CO_2 emissions, it must establish overall emission and/or fossil fuel use reduction goals, reduction schedules or formulae, allocation formulae, monitoring, reporting and enforcement provisions and mechanisms for financing and technology transfer. Such an agreement must do all of these things whether or not it provides a mechanism for trading of CO_2 emission or energy efficiency credits among sources in different nation states.

3 Application to CO2

The primary advantages of using marketable permits were distilled recently in the process of the IPCC discussions concerning response policies. Those identified included:

flexibility
direct control of emission levels
efficiency in pollution control
mechanism for trading among different greenhouse gases
incentives for development of non- or low polluting technologies.

(Working paper by Bertram et al. For IPCC/WG3-II/Doc 3)

In addition, permits would decentralized pollution control decision-making commensurate with the numbers of sources involved. An international CO_2 (or greenhouse gas) trading program also can accommodate a variety of separate national implementation strategies and policies. No nation would be compelled to achieve its control obligations through trading. Lastly, by linking sources and sinks in one comprehensive strategy, an explicit mechanism of self-interest is established between along the often divisve North and South axis.

3.1 Sink Stimulus

CO_2 trading is likely to produce the same proliferation in supply options as generated in the deregulation of the financial services industry. The huge variety of precisely tailored investment vehicles available in the current market are likely to be mirrored in the CO_2 (or greenhouse gas) permit markets. After all, a CO_2 trading program would create a new form of environmental currency. One direct effect would be the stimulus to develop sinks as well as source reductions.

Since tropical forests are a major sink for carbon and their burning or destruction at current rates constitutes some 15% of global CO_2 loadings, the question is how an international agreement can promote the retardation of the destruction or the re-establishment of any forests and whether a trading program can facilitate attainment of those goals.

The destruction and burning of tropical forests in countries such as Brazil and Indonesia contribute a significant fraction of their CO_2 budgets. Thus, if such countries allocated their CO_2 emissions targets proportionately to the forest sector and fossil fuel sectors, Indonesia would have to take steps to prevent any increase in the destruction of its forests; Brazil would have to implement a program to decrease the rate of loss of its forests by 2% per year.

If tropical forest acres can be converted into CO_2 and energy efficiency equivalents, countries like Brazil and Indonesia might find it economically attractive, as well as environmentally sound, to retard the destruction of their forests even faster or to implement restoration programs where, in the process, they can earn CO_2 credits which their own industry could use or which they could sell to foreign firms or governments. Those countries in turn could use the revenues from the sale of such credits to finance programs to retard forest loss. A trading program authorized under an international convention/protocol could therefore provide such countries with substantial economic incentives to protect their forests over and above the regulatory mandates of such a convention.

While a convention should encourage the creation and protection of carbon sinks, such as forests, defining quantitatively the magnitude, size and rates of loss of those sinks is an enormous undertaking. Satellite monitoring is a critical tool. But this effort must be made whether or not international trading of credits involving sinks is authorized so long as CO2 emissions from destruction or creation of such sinks is incorporated into a convention.

One of the primary advantages of greenhouse gas trading is the fact that it is quantity denominated. Everyone can readily determine what is required and what has been accomplished. The program is denominated in environmental terms. There are no conflicts over revenue and its distribution internationally. It is completely consistent with any underlying national implementation policy. It is voluntary, no one is compelled to trade. Depending upon the initial distribution of CO_2 permits (reduction responsibilities), it also contains an explicit mechanism for North-South flows of funds. Tropical forests in less developed nations would be linked to fossil fuel combustion in developed nations.

4 Alternative Designs

There are a variety of alternative greenhouse gas trading program designs. Two specific alternatives are discussed below which represent polar extremes are discussed. In both cases the limiting, but simplifying assumption of CO_2 trading is introduced.

The first case involves allocating permits to fossil fuel producers. The second would assign permits to fossil fuel end users. The designs differ largely in effect, extent of trading, and administrative ease.

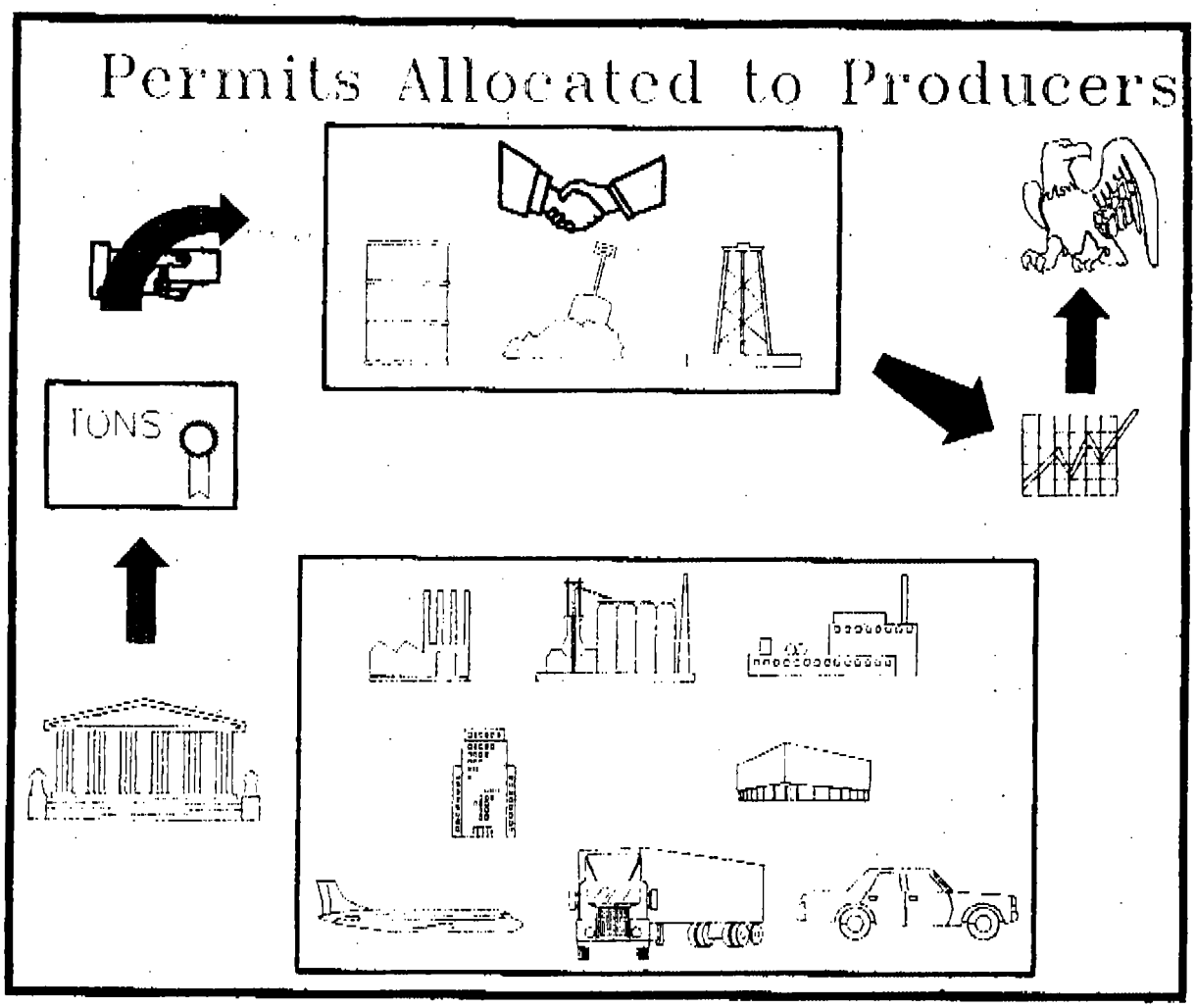
4.1 Allocation to Fossil Fuel Producers

Allocating permits to fossil fuel producers as indicated in the diagram below, would restrict the bulk of trading activities to energy producers and sink managers. In the case of greenhouse gas trading, the capture and destruction of banked CFCs and halons would also be a valuable source of reductions as would the recovery of coalbed methane. In both

designs the control point for compliance is the fossil fuel producer who would be required to turn in a sufficient quantity of permits to cover annual production.

End users would perceive the program in economic terms much as a tax on carbon, i.e. they would face higher energy prices. In fact, users would be offered energy at two prices -- one price with the permit bundled in and another with the permit to be supplied by the fuel purchaser. Buyers would evaluate the costs of generating new permits versus the price differentials charged by the energy producers.

As indicated above, the permit program, although behaving somewhat as a tax policy in effect, would nonetheless differ in at least two critical aspects. First, the "tax" would be determined by the market in permits, i.e. by the decisions of private actors rather than through legislative or bureaucratic means. Second, sinks are encouraged.

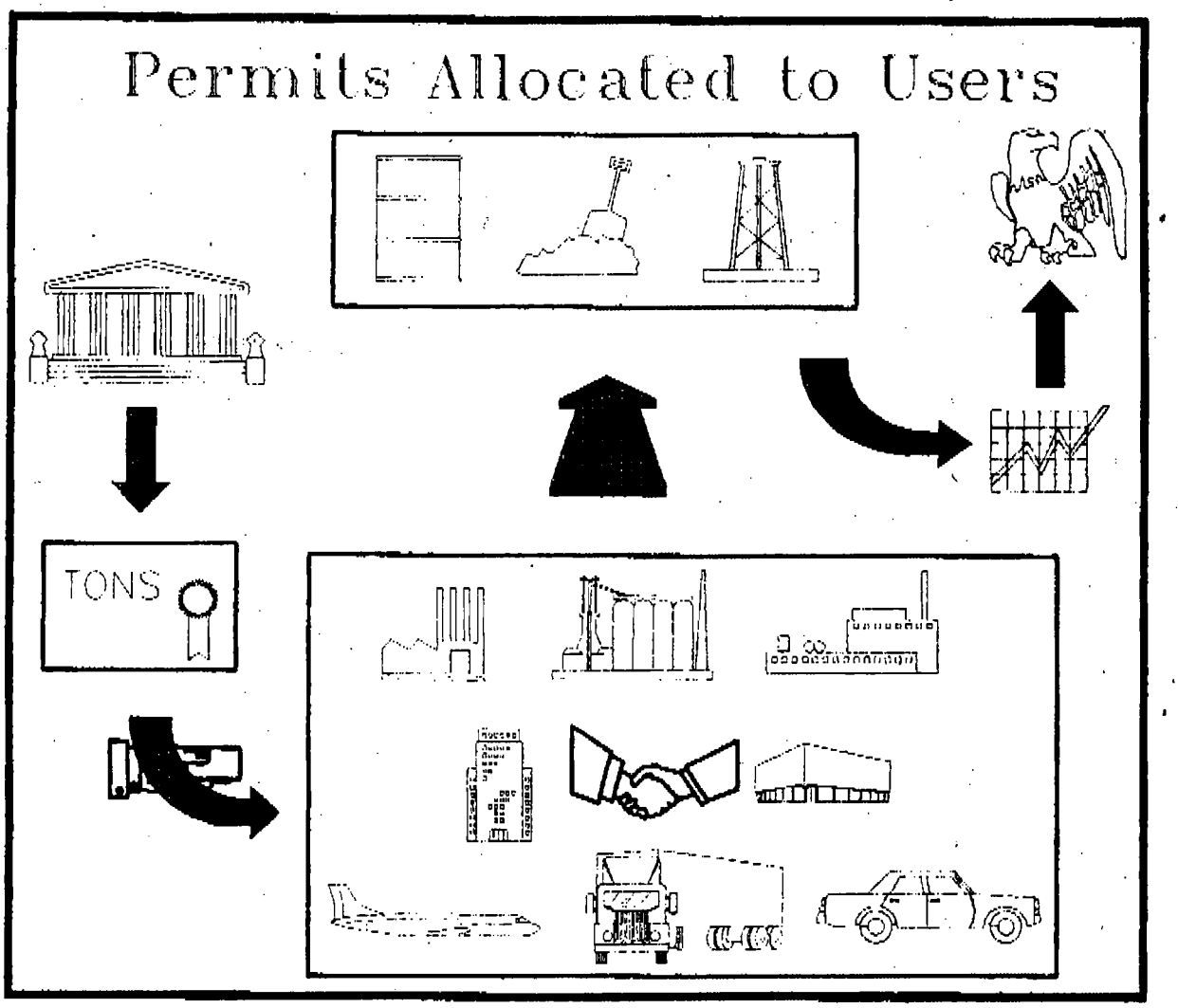


4.2 Allocation to End Users

An alternative design for a CO_2 trading program would allocate permits to end users of fossil fuels as depicted in the figure below. The big liability of this approach is the creation of baselines for all of the

sources involved. Even if a line were drawn at major commercial and industrial consumers, literally thousands of firms' records would have to be evaluated. The big asset is the direct stimulus to energy efficiency. Any energy use reduction below the individual baseline is by definition a credit that can be transferred. This direct revenue mechanism would be a dramatic boost to fossil fuel conservation efforts.

This design would still encourage sinks and reductions in other greenhouse gases for the purposes of trading. Fossil fuel producers could still offer two tiered prices, but the main permit supplies would come from end users who would pass permits covering their purchases to producers. Compliance would still be measured at the point of production of fossil fuels.



4.2.1 Technology Transfer

A major benefit is that such a system provides manufacturers with an economic incentive to develop and use technology that uses fossil fuel energy more efficiently than national regulations (promulgated to be consistent with an international allocation formula) alone would provide or that relies on renewable sources of energy. It could also provide large industrial or commercial users of energy systems with incentives to make

efficiency investments. The reason for this is that such a manufacturer may be able to sell (or large users may be able to earn credits) based on this added efficiency. The ability to sell CO_2 emission credits produces economic value for the more efficient technology. Internationally, a potential benefit of a trading program is that, if properly designed, it could promote transfer of energy efficient technologies from highly industrialized to less developed countries.

To simplify this illustration, let us look at how an international agreement could affect the energy efficiency of, initially, one major appliance, namely, refrigerators, and, then, a broader range of fossil fuel energy systems. Furthermore, by way of illustration, let us assume that the industrialized countries of the world are required by such an international agreement to reduce their emissions of CO_2 by prescribed amounts annually or in multi-year phases, that countries with high rates of forest loss would have to reduce their rates of CO_2 growth modestly and that many developing countries, such as India and China, with very low but growing per capita rates of CO_2 emissions would be authorized to increase those rates modestly for some period of time. The CO_2 control/reduction schedule should be pre-announced both in the convention and each national program so that firms and government agencies can plan and make their investments accordingly.

For the U.S., or any other industrialized country, to meet internationally prescribed CO_2 reduction goals, it would have to consider a range of strategies, including adoption of progressively more stringent energy efficiency standards for vehicles, building heating, ventilation and air conditioning (HVAC) and lighting systems and major appliances (CHVAC), such as refrigerators. Under the National Appliance Energy Conservation Amendments of 1988, the U.S. Department of Energy (DOE) has the authority to promulgate energy efficiency standards for many household appliances, including refrigerators. DOE has in fact recently promulgated new energy efficiency standards for refrigerators and freezers to take effect January 1, 1993, 54 Fed. Reg. 47916 (Friday, Nov. 17, 1989). In announcing these new rules, DOE has claimed that they will improve overall refrigerator/freezer energy efficiencies by 25% compared to products on the market today. Each nation could translate CO_2 emission controls into percentage improvements in energy efficiency for all industrial sectors.

To take advantage of a trading program, the DOE standard-setting program for appliances such as refrigerators could be revised along the lines of the Department of Transportation's Corporate Average Fuel Efficiency (CAFE) standard-setting program for automobiles. A car manufacturer complies with the applicable CAFE standard if the average fuel economy of its entire fleet sold in a given year meets the mandated fuel efficiency level. Energy efficiency standards for refrigerators could be similarly set so that the average refrigerator made and sold by a manufacturer complied with the standard in effect in a given year.

Under a trading program, a manufacturer (or importer of a foreign-made refrigerator) that produced and sold in the U.S. refrigerators the average energy efficiency of which was better than the applicable product standard could obtain energy efficiency (surrogates for CO_2 emission) credits. These can be statistically translated into CO_2 equivalents using average lifetimes of appliances, etc. DOE or some other agency would have to certify the issuance of these credits based on reliable information supplied by the manufacturer. Similarly, a manufacturer whose average refrigerator did not meet the prescribed energy efficiency standard for the applicable year would have to purchase credits. Manufacturers of refrigerators and freezers could therefore buy and sell credits amongst

themselves. The end result would be that the average refrigerator/freezer manufactured and/or sold in the U.S. would meet the efficiency standard although the average appliance of any single manufacturer need not.

If well-designed, administered and enforced, this arrangement would give all manufacturers of refrigerators/freezers added flexibility in planning and timing the making of investments to increase the energy efficiency of these appliances. This added flexibility would provide cost savings and therefore afford economic efficiencies to the overall program. In addition, one or more manufacturers might find the economic incentive provided by the potential to earn and sell efficiency credits great enough to invest larger sums in conducting research on and developing even more efficient technologies than the applicable standards prescribe. So long as at least one manufacturer takes advantage of these incentives, the introduction of improved technologies would occur at a faster pace than otherwise.

Domestically, in the framework of a U.S. program designed to meet CO_2 emission goals, this kind of approach could be expanded so that efficiency standards applied to all products that utilize energy. The manufacturers/importers of those products - be they cars, lighting systems or industrial boilers - could then obtain credits if their average products were more efficient (or emitted no CO_2 because they used solar energy) than a prescribed baseline and could purchase credits if the contrary were the case. Such credits could be fungible and tradeable among manufacturers of all products subject to the overall program. Further, energy suppliers could directly bundle CO_2 credits along with their fuel. In effect, the use of that part of the sector's fuel would be CO_2 neutral. Permits could be generated or held by anyone. Third parties could also participate in this program. For example, a supplier of energy efficient systems for commercial buildings or industrial plants would have an incentive to retrofit such buildings or plants for a share of the CO_2 credits.

For this program to function effectively, manufacturers would have to furnish reliable information about the energy efficiency of their products to the responsible agency that in turn would certify the issuance of credits and report any trades. However, most of this information would have to be gathered and reliably reported, stored and analyzed for a national program designed to meet CO_2 emission goals even in the absence of a trading feature.

Other industrialized countries might adopt similar kinds of regulatory and economic incentive programs to comply with their allocated energy efficiency/CO_2 emission targets. If such programs included, among other things, a procedure for generating and certifying efficiency credits for refrigerators and freezers, the U.S. and such other industrialized countries could enter into bilateral agreements whereby manufacturers of those appliances could buy and sell credits internationally on the same basis as described above.

To give a more concrete example, let us assume that western European countries or the European Community (EC) as a whole would have to reduce CO_2 emissions annually by rates or amounts prescribed in an international convention. Those rates may be different from those applicable to the U.S. The EC could establish efficiency standards for refrigerators and freezers. The efficiency standards in force in those countries or throughout the EC in any particular year might be different from those in the U.S., in part reflecting differences in applicable national goals or, within those countries or groupings, differences in allocating responsibilities for meeting national goals among different sectors of their economies.

With a bilateral agreement in place, a manufacturer of refrigerators/freezers selling in both the North American and western European markets might produce and sell appliances which on average were not as efficient as required in one market but more efficient than required in another market. That manufacturer would be eligible for credits in the latter market (i.e., the market where the appliances were sold). It could then use those credits to compensate for its failure to meet the applicable standard in the former market. Or, pursuant to contract, a more energy efficient manufacturer in the latter market could sell or transfer credits to a manufacturer in the former market.

This discussion has been limited to manufacturers of refrigerators and freezers to present a concrete example of how a bilateral credit transfer system could operate. As with any national program, such a bilateral arrangement could be designed to cover other appliances or all energy-consuming systems. Under such an arrangement, energy efficiency baselines for such systems would be set by the participating countries. Those baselines could be modified in accordance with a prescribed schedule. Energy efficiency or equivalent CO_2 emission credits could be traded, bought or sold amongst all manufacturers/importers of such systems. The arrangement would set forth the procedures for monitoring, certification of credits, reporting of transfers and enforcement. It could also authorize participation in the market for credits by third parties. If planting of trees as a sink of CO_2 were included in the national program, the energy efficiency credits would have to be denominated in CO_2 equivalents as well.

Such bilateral agreements expand the universe of manufacturers who could benefit from the investment and flexibility provided by such trading arrangements. CO_2 concentrations in the atmosphere are a function of global loadings and are not affected by the geographic distribution of individual sources. The fact, therefore, that one industrial country emits a smaller total load in a given year than an international convention/protocol prescribes while another country emits a concomitantly larger total load as a result of trading among those countries is irrelevant in terms of environmental protection.

Bi-lateral or international agreements that authorize trading of energy efficiency/CO_2 emission credits between an industrialized country, and a developing country, are also possible. A major objective here would be to design the international allocation system so that firms that decided to take advantage of the trading program would indirectly be contributing to the kinds of technology transfer and financing goals described in the Report of the Second Session of IPCC Working Group III/Response Strategies Working Group, Geneva, 2-6 October 1989, in particular, "Implementation Measures on Technology Development and Transfer Measures" and "Implementation Measures on Financial Measures."

To illustrate how this transfer mechanism might work, consider the example of a highly industrialized country that is a large emitter of CO_2 today (HIC) and a less developed country (LDC) that is a low emitter of CO_2. Let us assume that the LDC intends to increase its coal-fired electrical generating capacity substantially over the next 10 years. Some part of this capacity is to be used to generate electrical power for a rapidly increasing number of refrigerators and freezers in that country. Under an international convention/protocol, the LDC might be allowed to increase its total CO_2 emissions at a fixed rate of growth, but lower than otherwise projected.

One way for the LDC to decrease its projected CO_2 emissions growth rate as mandated by an international agreement would be to set efficiency standards for refrigerators and freezers. While those standards may require production and use of more efficient refrigerators and freezers than might be the case absent an international agreement, those standards might not be as stringent as those that the HIC (any hypothetical highly industrialized country) would have to adopt to meet its CO_2 reduction obligations.

Under this example, a firm located in the HIC might find it economically attractive to enter into a joint venture with a firm manufacturing refrigerators/freezers in the LDC. Pursuant to such a joint venture, the HIC firm could provide the know-how and right to use the more energy efficiency technology to the LDC firm. That firm would then be able to manufacture more efficient refrigerators/freezers than the LDC regulations required. In turn, taking advantage of that advanced technology, the LDC firm would obtain credits that it would then transfer to the HIC firm pursuant to the terms of the joint venture. The HIC firm could then use those credits to permit it to manufacture and/or sell in the HIC's market refrigerators/freezers that were less efficient than the HIC's standards otherwise prescribed. Alternatively, depending on the law of the host country, the HIC firm might simply invest in new plant capacity in the LDC to manufacture more efficient refrigerators/freezers than LDC regulations mandate and obtain credits accordingly for its use in the HIC.

The HIC firm (any firm in any industrialized country) might find this arrangement to be economically attractive if it could save significant funds by postponing investments necessary to meet the domestic standards. Because the firm would be obtaining credits under this scheme from a firm in a less developed country, it would be willing to lease or transfer the refrigeration technology at lower cost than it would otherwise. In turn, the LDC firm could make and sell the more efficient refrigerators at less cost than it would otherwise.

Under this example, the potential to obtain credits in a developing country from investments that increased the energy efficiency of appliances made there would create an economic incentive on the part of a firm in an industrialized country to transfer technology and, in effect, to finance the transfer of that technology beyond what otherwise would be the case. The point is that a well-designed protocol that encourages such international trading of energy credits could promote least cost energy efficiency investments (as well as renewable energy investments) on an international basis that would accomplish international equity and technology transfer objectives as well.

As a general proposition, the tougher the CO_2 reduction goals that industrialized countries must meet, the more their manufacturing firms should be inclined to look for such joint venture opportunities in less developed countries as a source of credits. In addition, so long as developing countries face constraints on the rate of growth of their CO_2 emissions, firms there have an incentive to enter into such joint or contractual arrangements as well.

5 Implementation Issues

International trading in greenhouse gas permits can be established in a limited number of coordinated phases. The first phase would build the infrastructure necessary to facilitate such a global market. This phase would be devoted to the creation of international monitoring systems, tracking and recording systems, and market clearinghouse. The second phase could be a limited permit system more narrowly focused as an offset

program targeting new sources. The final phase would be the development of full scale trading perhaps only for CO_2 initially with other gases included as the capacity of the trading system is expanded.

For an international convention that imposes limits on emissions of CO_2 from burning of fossil fuels and destruction of forests to function effectively, the participating nation states must be willing to and be able to obtain and report reliable information about fuel use and forest loss. The convention must also provide for a credible enforcement mechanism and the establishment or strengthening of an international agency to receive and assimilate data and to assure compliance.

If the convention authorizes bilateral or multinational trading of CO_2 emission credits, that international agency or some international body would have an additional role to play. More specifically, at the national level, any country with a domestic trading program would have to have in place an administrative mechanism for certifying that individual firms were entitled to credits or had to acquire credits to comply with standards. If those credits were to be tradeable to a source in another country, some international agency should have the authority to record those credits and to assure that the national credit certification program was viable and accurate. Since a country might have an incentive to inflate its eligibility for credits, this international agency would need additional resources to assure reliable national reporting of information and valid credit issuance programs.

A trading system can also help to assure the integrity of any system of emissions limits. As industrial enterprises -- or even governments -- attempt to comply with CO_2 limits, technical or economic factors will inevitably prevent some from complying at some times. Without a trading system, a variance system (formal or simply by non-enforcement) will inevitably develop. A formal system will in turn require technical or economic criteria for evaluating variance requests and bureaucracies to apply those criteria. In a comprehensive, worldwide system for regulating CO_2 emissions, the variance bureaucracy may become comparably massive. Inevitably also, those bureaucracies will not close needed economic enterprises for the sake of what may appear "temporary" violations of CO_2 limits. The problem could lead to distrust between nations and diminishing willingness to make needed sacrifices.

A trading system should eliminate the need for variances by allowing industries and nations that cannot comply with limits to purchase credits. No criteria would be necessary to evaluate variance requests, and the sole task for bureaucracies would be the registration and verification of the transfer. Enforcement officials would not need to negotiate complex compliance orders, but simply to order the purchase of credits. Enforcement could also be more credible because the purchase of credits should often be less draconian than shutdown of enterprises. In addition, the failure of some enterprises to comply with initially set limits should always be matched by compensating reductions. And because a market mechanism will replace bureaucratic judgment, those enterprises that do not comply with initial limits should do so because of real economic needs not political influence.

5.1 The Offset Program

One of the first direct implementation steps for CO_2 trading is an offset requirement for new CO_2 sources. Major new sources would include new fossil fueled electric generating stations, new industrial boilers, and cogeneration facilities selling power into the grid. Such a program would:

* begin reduction of accumulation of greenhouse gases in the atmosphere
* establish administrative mechanisms to facilitate trading (create infrastructure consistent with the current U.S. response policy position)
* allow utilities to obtain regulatory credit for CO_2 reductions produced as a by-product of the acid rain control program
* stimulate private market development of CO_2 reducing technologies.

The heart of the program is the ability to create and transfer CO_2 credits. Any CO_2 reduction meeting the certification requirement would constitute a legitimate CO_2 credit available for offset. The program would create explicit procedures for the certification of several identified offset credit sources. In addition, these procedures would allow any source to receive credit for CO_2 reductions for any such reductions that can be demonstrated to have been explicitly created for this program and which constitute CO_2 reductions that would have normally been emissions.

Examples of sources of CO_2 offsets include energy efficiency investments, vehicle fuel efficiency improvements beyond the CAFE baseline, appliance efficiency improvements beyond the mandated standards, fuel switching to less CO_2 intensive fuels, and the planting of trees. Putting the burden of proof of new reductions upon the potential offset supplier allows the program to be open-ended and to encourage the widest diversity of offset sources to be developed, demonstrated, and engaged. These sources should include other greenhouse gases, e.g. methane, and N_2O. The greenhouse trading ratios to represent radiative differences between gases could be established by EPA by regulation in consultation with NOAA.

Certification for some sources will require the development of specialized rules and methods. For example, in the case of automobiles, reductions beyond the CAFE standard would be translated into a quantity of CO_2 through a statutory assumption concerning the actuarial life of a vehicle. In the case of trees, the uptake rates of individual species by location and soil type would be specified by the EPA in consultation with the U.S. Forest Service. Improved uptake rates could be prospectively established through demonstration projects. For example, new more intensive management procedures could improve uptake rates and should not be precluded from being developed.

In order to insure that a sufficient supply of offset credits is available, an offset bank could be created at the Environmental Protection Agency. Sources generating reductions can be certified for credit as soon as the reductions are produced. These reductions can then be maintained as an available supply by EPA. This bank can function like an information exchange identifying the owners of certified reductions. Information maintained would be contact, quantity and minimum bid price.

For some offset supplies such as trees, it will be critical to assure that the CO_2 sequestering value of the offset is maintained. For example, for trees, it is critical that the stored carbon credited as an offset is maintained as stored carbon. For example, if a forest used for an offset is subsequently harvested, only those amounts of wood transferred into a relatively permanent use like housing stock should be credited with maintaining the stored carbon.

Each year, each source subject to the offset provisions would be required to deposit with the Administrator sufficient CO_2 offsets to fully compensate for its CO_2 emissions in that year. Each year all sources regulated by the program would submit to the EPA a report of CO_2 emissions. Each source would be required to adopt CO_2 emissions monitoring or a monitoring method of equivalent accuracy. Each year, the Administrator would publish a report of such emissions.

Sources failing to comply would be subject to a penalty per ton of CO_2 not covered by an offset. The penalty should be adjusted by the producer price index in order to assure its continued economic force over time. In addition, the emitter would be required to submit a plan to the EPA Administrator to be approved by the Administrator for the production of offsets to compensate for the uncompensated emissions.

6 Conclusions

In the debate about greenhouse gas policy much energy has been expended in the prices versus quantities issue. In this sense advocates of economic incentives have been arguing over rearranging the deckchairs on the Titanic. In actual implementation, the distinction is likely to blur. For example, if the penalty for failing to hold sufficient CO_2 permits is a fine levied per unit of excess CO_2 discharged as in the acid rain case, then that fine becomes the upper limit of the price for CO_2 permits. On the other hand, if not only a fine is levied but a requirement to produce a compensating CO_2 reduction, then there is no price ceiling and the systems do not necessarily diverge.

In any event, the fines, if collected internationally, could provide a source of technical assistance financing for less developed nations, an issue which bedeviled the Montreal Protocol and is likely to plague greenhouse gas negotiations. As previously noted, however, the trading mechanism provides an explicit incentive for investment in LDCs to generate extra reductions.

International greenhouse gas permit trading has several critical advantages unmatched by alternative policy options. First, marketable permits would provide the greatest spur to innovation in both low polluting technologies, emission control options, and pollutant sinks. This latter aspect is an important and often overlooked feature of any greenhouse policy. Providing the option of producing additional permits over time lessens the impact of greenhouse gas control on economic performance. Permits also provide an explicit mechanism for reallocating scarce resources, namely CO_2 permits, over time and space. Certainly fixed international obligations could be periodically renegotiated, but it difficult to imagine that such a process could even begin to approach the efficiency of a genuine global market. Lastly, a system of marketable permits provides all parties with a relatively simple means of determining performance. The sum of permits transferred to control authorities at any one point in time measures total emissions.

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